ENVIRONMENTAL Fact Sheet

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

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Bedrock (Artesian, Drilled) Well Design

For the most part, this document assumes the reader will be installing a new well. See comments near the end for suggestions concerning inspection of existing bedrock wells. For well abandonment, visit the fact sheets webpage at www.des.nh.gov/organization/commissioner/pip/factsheets/dwgb/index.htm and scroll to WD-DWGB-1-7, "Well Abandonment and Decommissioning."

Government Regulations

State Regulations: A person or firm in the well construction business must be licensed by the New Hampshire Water Well Board of DES. A home owner can install their own well without a license. The Board requires the submission of a "well completion report" describing the well's design, construction, the soil and rock conditions encountered, and the well's yield within 90 days of the completion of the well installation.

There are statewide design criteria rules for bedrock (artesian) well construction and placement. These rules were originally adopted by the Board in 1983 and subsequently revised. The rule number is We 100-900. There are no state requirements concerning minimum well water quality or quantity for any well.

Finally, when selling a home with an on-site water system, RSA 477:4-C requires disclosure of the water system's location, malfunctions, date of installation, date of the most recent water test, and whether or not the seller has experienced a problem such as an unsatisfactory water test.

Local Regulations: At the local level, some towns may have local permit requirements relative to the placement, construction, water quantity or quality for private wells. Please contact your local health officer or code enforcement office for more information.

Evaluating a New Water Source: Determining How Much Water You Use

To determine needed well yield, you must first estimate your water demand. A typical household requires approximately 5 gallons per minute (gpm) to meet modest domestic water needs. However, as little as 1 to 3 gpm could be tolerated if there is sufficient water storage. Factors to be considered when determining your family's minimum demand on your water system include: the number of water uses that you have, their flow rates, how many of these uses could occur simultaneously and for what duration. For more information on minimum well yield, visit the fact sheets webpage at www.des.nh.gov/organization/commissioner/pip/factsheets/dwgb/index.htm and scroll to WD-DWGB-1-8, "Recommended Minimum Water Supply Capacity for Private Wells."

Determining How Much Well Yield You Need

The minimum well yield that will satisfy your family's water needs is more difficult to identify. A low yield well (1-3 gpm) may be acceptable if one makes use of water stored in the well casing or in storage tanks. This well casing storage may not be available if the watertable drops during the summer and fall. The typical 6-inch well casing has a storage volume of approximately 1.5 gallons per foot of water depth.

The document “Well Yield, How Much Water is Enough” is available from the Water Well Board for $2. The United States Department of Agriculture Farmers Home Administration guidelines require a minimum well yield of 1,200 gallons for a four-hour test period.

Storage in the well may allow installation of a higher capacity pump if the duration of pumping will be short. In such cases, a low water cut-off device should be installed to prevent overheating damage to the pump’s electrical motor. Large storage tank(s) installed in your basement can serve this same function of accumulating water during periods of low demand. However, an additional pump will be necessary to pressurize this water.

Drilled (artesian) wells are somewhat less affected by drought conditions than dug wells. Drought effects can be minimized by planning to drill a deep well. If a well yield is only a few gpm at a well depth of 100-200 feet, we recommend that the well be drilled deeper. On the other hand, if there are only a few gpm at depth of 700-800 feet, it is reasonable to end drilling on that particular well.

It should also be noted that a well's yield may change with time. A 1 gpm loss on a 2 gpm well is critical while a similar change in a 10 gpm well is not too significant. Thus, one should try to develop the maximum well yield possible, within economic reason, when the well is first drilled.

The distribution of groundwater in the bedrock is very irregular and depends on the distribution of rock fractures, their size, orientation, the number of interconnections with other fractures, and with the overlying water-bearing soil to name but a few factors.

Typical New Hampshire Bedrock Well Statistics
Most wells for household use are in the 100-500-foot deep range; a few are over 1,000 feet. The median depth of bedrock wells in New Hampshire is approximately 295' deep. The median yield was 6.5 gallons per minute. More specific well information for your locale can be obtained from the Water Well Board.

Hydrofracturing to Increase Well Yield
Well yields can be increased by fracturing the bedrock immediately around the drill hole. One technique to accomplish this fracturing is to pump high volumes of water into the drill hole at pressures up to 3,000 pounds per square inch (psi). This process is called hydrofracturing. In the past dynamite, dry ice, and compressed air were used to accomplish this same fracturing. If hydrofracturing is being considered, ask your licensed water well contractor or the Water Well Board about the various methods available. For detailed information on hydrofracturing, visit the fact sheets webpage at www.des.nh.gov/organization/commissioner/pip/factsheets/-dwgb/index.htm and scroll to WD-DWGB-1-3, “Bedrock Well Development by Hydrofracturing.”

Water Quality Considerations
Bedrock wells have generally been believed to have superior quality to dug wells. This statement depends on the water quality factor being discussed. Some water quality characteristics in bedrock wells, such as bacteria quality, are improved due to the longer time required for the water to percolate through the soil and into the bedrock, and the tighter construction of a bedrock well casing due to superior materials.

The occurrence of iron, manganese, taste and odor in bedrock wells is approximately the same as in dug wells. On the other hand, bedrock wells can experience contamination from the rock they are drilled in and can experience approximately one or more of the following water quality problems: arsenic (15 percent occurrence frequency), fluoride (3 percent), and radioactivity, including radon (30 percent), radium (1 percent), uranium (5 percent), and compliance gross alpha (3). Radon gas occurs in all wells. In bedrock wells, radon concentrations are, on average, much higher than those for dug wells. Dug wells rarely experience the chemical problems mentioned above, but are much more affected by bacterial, “backyard” pollutants and low volume associated with droughts.

For more information on dug well design, visit the fact sheets webpage at www.des.nh.gov/organization/-commissioner/pip/factsheets/dwgb/index.htm and scroll to WD-DWGB-1-4, “Dug Well Design,” and WD-DWGB-2-1, “Suggested Water Quality Testing for Private Wells.”

Well Protection and Placement
Artesian wells take water from fractures in the bedrock. The fractures receive their recharge from the water table in the overlying soils. Care should be taken in what activities are allowed to occur near your well in order to prevent contamination. Bedrock wells typically are more immune to local pollution because the recharge occurs along the bedrock "fault line" over a long distance.

Examples of chemical hazards to your well include the application or inadvertent spillage of fertilizer, pesticides, and inappropriate disposal of old crankcase oil, anti-freeze or solvents, or waste salt brine from water softeners to name a few. Thus, the use of chemicals in your backyard or in that of your uphill neighbors may negatively affect the quality of the water from which your well draws. Tests for modern pollutants involve complex and costly laboratory procedures. Thus, the best and least costly approach to achieving good water quality is prevention of pollution rather than treatment after the fact.

The following protective distances are required or recommended when locating a well for a private single family home:

a. Surface water and drainage culverts should not pass within 25 feet of a well; 50+ feet is recommended.
b. Animals should not be penned or tied within a minimum of 20 feet of a well; 75+ feet is recommended.
c. Leach fields and septic tanks shall not be located within 75 feet of a well.
d. Wells should not be located within 50 feet of the right-of-way line of roads, preferably more.
e. Wells shall not be placed within 75 feet of adjacent property which you do not control. (See RSA.485-A:30-b). If placement is made necessary within 75 feet, a standard release form is required to be signed by the well owner and given to DES, the town health officer, and the registry of deeds. Since most zoning codes require a 10 foot setback from property lines, this distance is affectively 65 feet.
f. A well should not be placed in locations subject to ANY flooding unless the immediate vicinity (25 foot radius) of the well is built up above the maximum possible flood level.

Visit the fact sheets webpage at www.des.nh.gov/organization/commissioner/pip/factsheets/dwgb/index.htm and scroll to WD-DWGB-21-1, "Site Selection for Private Drinking Water Wells," and WD-DWGB-21-4, "Best Management Practices for Well Drilling Operations," for more information pertaining to locating private wells.

Fracture Trace Analysis
Although costly, there are modern techniques for determining the most advantageous location for a bedrock well. These techniques use satellite photography to identify bedrock fractures hidden below the ground surface. Knowing these areas, the well can be located where the rock conditions are most favorable for high water yields. This process is called "fracture trace analysis." The cost of such analysis would typically exceed the cost of drilling the well. Because of the high cost, this procedure is not normally used for private wells. DES and the US Geological Survey have made a substantial effort to identify and map bedrock fractures for all of New Hampshire. Please call the Water Well Board for more information.

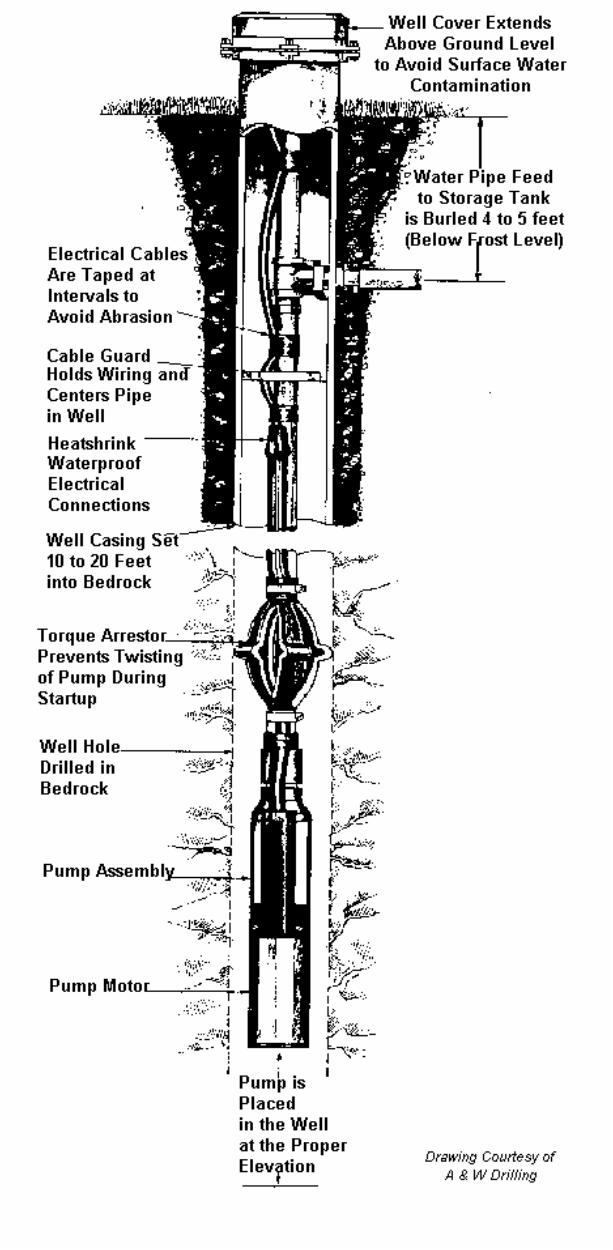
Choosing the Well Type You Will Purchase
Based on the considerations above, such as soil depth, water needs, and existing pollution, you should now be ready to choose the type of well that you believe is best for your lot and home.

Contracting With a Well Driller
Prior to actual drilling, you will need to provide the well driller with guidance as to what concept will govern the amount of work to be done. Typical options include: a) drill to a specific depth, b) drill to a specific well yield, or c) drill to a specific budget amount. The nature of the well installation contract is strictly between the well owner and well driller.

Drilling Techniques
Two techniques are used to drill artesian wells. In the **rotary process**, a drill bit on a long shaft is rotated to grind and crush the rock at the bottom of the well hole. A water/mud slurry is pumped down through the rotating drill bit to flush the rock cuttings up and out of the well. These cuttings overflow the casing and typically fill the annular space between the outside of the steel well casing and the surrounding soil. This action normally produces a tight seal between the steel casing, the bedrock, and the soil. This sealing action generally minimizes the need for cement grouting of the steel casing into the bedrock. Most bedrock wells are drilled using the rotary process.

In the **percussion process**, otherwise known as cable tool drilling or "pounder" drilling, a falling weight is used to pulverize the bedrock at the bottom of the drill hole. Periodically a separate, long thin bailing device is used to remove the rock cuttings from the drill hole.

Some experts contend that the percussion process better fractures the rock in the immediate vicinity of the hole, and the bailing of water and pulverized particles keeps the rock fractures from becoming clogged with the drilling mud and rock cuttings. These two actions are believed to result in higher yields of those wells drilled by the percussion process. In recent years, drill bits for the rotary drilling machines have been redesigned to include a percussion action to better fracture the rock. Rotary drilling is normally less expensive and much less time consuming than percussion drilling. DES does not recommend any one method of construction over another.



Drilled Well Configuration
Steel Casing
A steel pipe is normally seated into a socket in the bedrock by 10-20+ feet. Cement grouting the casing to the bedrock is suggested by some experts to ensure a good seal. Grouting is expensive and is not the normal practice in New Hampshire. A hardened steel "drive shoe" is required on the leading edge of the steel casing. The drive shoe improves the alignment and sealing of the steel casing to the bedrock socket. Plastic well casings are not recommended.

Pipe and Cable Spacer (Cable Guard)
Cable spacers prevent the abrupt swinging of the discharge pipe and power cable within the drill hole as the pump starts and stops. Uncontrolled, this action can result in abrasive damage to pipe and wires resulting in possible short circuit of the power cable. Spacers are placed on the discharge line, every 20 feet or so, to position the power cable and discharge pipe in the center of the drill hole.

Anti-Torque Device
A torque arrestor prevents the twisting of the pump in the well at each start and stop of the pump motor. This will also extend the life expectancy of the discharge line and power cable. The anti-torque device recognizes that when the pump impellers begin to turn in one direction, the pump body turns in the reverse direction.

Water Supply Line and Pump
A submersible type pump is most often used in bedrock wells. The pump is typically set so as to provide at least a 20-50 foot clearance between the bottom of the well and the submersible pump. Jet type pumps can be used but are not energy efficient.

Drilled wells often act as electrical grounds. Lightning protection of the motor and electrical controls is recommended. The National Electric Code requires a ground from the home's electric service and pump to the well casing. Provide a minimum of five feet of cover over the water line to the home for frost protection. Before backfill, take field measurements and draw an accurate sketch of the precise route of the water line.

Duplicate this sketch, laminate and attach one copy to your pressure tank and one to the water system fuse box. In the basement, seal around the electrical conduit to reduce radon migration into the home.

Jaswell Seal (Not Shown)
In some cases, poor water quality from certain fractures, or a poor seal of the casing to the bedrock, can be eliminated by sealing off particular fracture zone(s). This can be achieved by the use of special mechanical seals (e.g., a Jaswell seal) or concrete grouting. A Jaswell seal consists of a 4-inch-diameter pipe that is placed within the well, at the proper elevation, and sealed at one or both ends. It should be recognized, however, that it is very difficult to locate those fractures that contribute poor quality water versus those that contribute good quality water. In addition sealing off poor water bearing fractures will reduce the well's pumping capacity. A Jaswell seal complicates the installation of the anti-torque device and cable spacers.

New Well Follow Up: Determining the Well's Safe Yield
You should know the well's safe yield. The safe yield of a newly completed well can be determined (and the well can be flushed) by pumping water to waste continuously over a sustained period of 24 or more hours. The pumping rate should be measured by noting the number of minutes required to fill a known volume container (such as a 20/32 gallon trash can). The water level in the well should be measured as the pumping continues.

The intent of the test is to develop an equilibrium between the amount of water being pumped out of the well and the amount which is replenished naturally from the bedrock. The discharge should be piped at least 200 feet from the well, and downhill, if possible, to prevent recycling or "double counting." Do not run this dirty water through your home plumbing.

If the drawdown in the well, caused by the pumping, is at a relative maximum depth and has stabilized, it can be considered as the maximum safe yield of the well. This test should be run in the early fall when the groundwater table is at its lowest. The water level (or drawdown) in a bedrock well can be measured by use of an air line, echo device, or electrical probes. Measuring the drawdown is the most difficult portion of a pump test. For more information on well yield, visit the fact sheets webpage at www.des.nh.gov/organization/commissioner/pip/-factsheets/dwgb/index.htm and scroll to WD-DWGB-1-13, "Determining the Yield of a Residential Well," or consult your well driller for detailed information.

Disinfection – Chlorination
For newly installed bedrock wells, or where well pumps have been recently replaced, it is most important to clear the well of rock cuttings and surface dirt before chlorinating the well or testing for bacteria. The well may have to be continuously pumped for days (or weeks, in a few new well cases) before this cleaning process is complete. Chlorination is NOT able to reach bacteria trapped inside accumulations of drilling mud or soil attached to the newly installed pump, pump electrical cable, or water discharge line.

The well can be disinfected by adding chlorine. One gallon of 5.25 percent sodium hypochlorite (i.e., common store bleach, such as Clorox) in 1,000 gallons of water will provide a good disinfecting solution. Remember the number of gallons of water in a bedrock well is approximately 1.5 gallons per foot of water in the bore hole. To add the chlorine, loosen the cap of the well, or unscrew the center nut in the cap, and pour in the chlorine solution. Then use a garden hose from your house to wash the chlorine off the top inside of the well, and to dilute

and push down the chlorine to the lower depths of the well. Run water through your plumbing system until you smell the chlorine. Use water sparingly for the next 12 hours, then flush out the chlorine. Do not flush large volumes of chlorinated water through your septic system, or into streams or lakes. For further information on disinfecting a water system, visit the fact sheets webpage at www.des.nh.gov/organization/commissioner/pip/factsheets/-dwgb/index.htm and scroll to WD-DWGB-4-11, "Disinfecting a Private Well." The approximate amount of chlorine could be 2 to 4 quarts of bleach for a 300-500 foot well. It is more environmentally friendly to begin with a lower concentration of chlorine on the first chlorination effort.

Testing New Wells for Water Quality
Remember all chlorine must be flushed from the well prior to collecting a new bacteria sample. Water quality samples with any chlorine residual can NOT be tested for bacteria or nitrate/nitrite. The presence of chlorine can be checked by using a chlorine test kit. These test kits are available though swimming pool dealers, or could be borrowed from neighbors with large swimming pools.

The DES laboratory can conduct a bacteria test and a standard analysis, which includes 13 water quality factors. For recommendations concerning water quality testing for private wells, visit the fact sheets webpage at www.des.nh.gov/organization/commissioner/pip/factsheets/dwgb/index.htm and scroll to WD-DWGB-2-1, "Suggested Water Quality Testing for Private Wells." Only DES sampling containers can be used. The time to process the standard analysis sample is approximately three weeks in the summer, and two weeks during the off season. Different containers are required for sampling radon gas, industrial solvents and hydrogen sulfide. Sampling containers can be obtained from the Laboratory Services Unit. Please contact the Laboratory at (603) 271-3445 or (603) 271-3446 or www.des.nh.gov/organization/commissioner/lsu/index.htm for more information and/or for current fees.

Inspecting Existing Bedrock Wells
The most common problem with an older bedrock well is that the top of the well is cut off below grade. If this is the case, it is quite possible to have bacteria problems caused by the leakage of unfiltered surface water directly into the top of the well.

Adding a Pitless Adaptor to an Existing Well If an existing bedrock well casing is cut off below grade, we strongly recommend that the casing be extended above grade and a pitless adaptor closure be used. This new extension must be water-tight at the connection point with the old casing. For information on "Extending Bedrock Well Casings," see WD-DWGB-1-14 at www.des.nh.gov/organization/commissioner/pip/factsheets/-dwgb/index.htm. The pitless adaptor not only provides the greatest protection against leakage and subsequent bacteria contamination, but also provides a visual indication of the well's location and easy access in all seasons.

For Additional Information
Please contact the Drinking Water and Groundwater Bureau and the New Hampshire Water Well Board at (603) 271-2513 or dwgbinfo@des.state.nh.us or visit our website at www.des.nh.gov/organization/divisions/water/-dwgb/index.htm. All of the bureau's fact sheets are on-line at www.des.nh.gov/organization/commissioner/-pip/factsheets/dwgb/index.htm.

Note: This fact sheet is accurate as of October 2008. Statutory or regulatory changes, or the availability of additional information after this date may render this information inaccurate or incomplete.